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ONDERSTEPOORT.

The Sandtampan *Ornithodoros Savignyi*: an ecological puzzle and an economic problem

GENERAL GEOGRAPHICAL DISTRIBUTION

The Sandtampan has been recorded from the Sahelian Zone in provinces of Mauritania, Sudan, Niger (French West Africa); Northern Bornu and Lake Chad (Nigeria); throughout Tchad (French Equatorial Africa); Northern Kassala; Khartoum, Darfur, Blue Nile, Kordofan (Sudan); in the Western Lowlands of Eritrea and French Somaliland; in the Eastern Lowlands of Ethiopia; scattered throughout Italian Somaliland, though generally rare; Northern, Central and Coast Provinces (Kenya); and Northern Province (Tanganyika); Southern Bechuanaland; Southern and Central South West Africa; and in the North West Cape in the districts of Kenhardt, Namaqualand, Mafeking, Vryburg, Kuruman, Gordonia and Hay.

It is recorded also from North Africa from Egypt, Libya, Tunis and Algeria; from Yemen, Aden, Palestine and Iraq in the Near East; and from the drier parts of India and Ceylon.

Hoogstraal (1956) expresses the opinion "*O. savignyi* appears to have erratically invaded Africa from the East . . . and part of its spread probably has been by camels, for in Northern Africa it is apparently most abundant [or through circumstances most frequently met with?] along camel routes". It would appear to me, however, that it has its origins in Africa, either in the dry Sahelian zones bordering on the Sudan, or in the Kalahari Thornveld of the North West Cape, of South West Africa and of Bechuanaland.

ANALYSIS OF ITS DISTRIBUTION IN SOUTHERN AFRICA

In an analysis of this sort, one must bear in mind that the records are most numerous for the populated areas and are necessarily scanty for the uninhabited areas. Also, with the increase in cattle ranching activities there seems to be an (apparent?) increase of tick activity, so that one must be wary of coming to the conclusion that the most thoroughly collected area is also the most heavily infested.

Fig. 1 shows *O. savignyi* to be present throughout north-western and western Vryburg; the western two-thirds of Kuruman, absent in the Langeberg Asbestos Mts. and Kuruman Hills; the western-north-western two-thirds of Gordonia; and spreading westwards and northwards into Keetmanshoop, Gibeon and Gobabis in South West Africa, all areas falling

SANDTAMPAN ORNITHODOROS SAVIGNYI: ECOLOGICAL PUZZLE AND ECONOMIC PROBLEM



into the geological Kalahari beds and sand belt. Our records across the border for Bechuanaland are but few; possibly the tick is equally prevalent in the triangle between Khanzi, Bray and the western border ("both from Kuli and Nojane we could fill gallon tins from below big trees and from some cattle kraals"—Correspondence). The few records from western Hay connect up with south-west Kuruman. The tick is reported absent on the south side of the Orange River in Gondonia, Kenhardt, Namaqualand (Goodhouse, Dabenoris, Koenabib to Klein Pella and Haramoep-Wortel) and north of the Orange in Warmbad. It crops up again in the Bushmanland of western Kenhardt at Annakop, Samoop, Namies, Gams and in the Koupsleegte area, spreading westwards mostly in association with the Koa Valley dunes, into Little Namaqualand; and is said to be present throughout in the sands of northern Namaqualand (Wolftoon, Henkries, Droëdap) except for the west coastal strip. It is absent from the Richtersveld. As yet I have not been able to locate the two farms Abbots Dam and Wonderdraai, Hope Town district, from which the tampan has been recorded; and have but little information about the farm Allemanskraal in the Steytlerville district.*

In South West Africa it is present, and apparently abundant, throughout the Kalahari sand-belt of Keetmanshoop, Gibeon and Gobabis, up to the level of the Epukiro River (lat. $21^{\circ} 30' S.$), but absent in the Kaukaveld. Otherwise it is ubiquitous and exceedingly plentiful everywhere to the south of Rehoboth ($23^{\circ} S.$). It is also present in the west all along the Namib, though it is consistently absent from the Brandberg; as also from the shifting, shadeless southern dune belt, which extends from the Orange River to the Kuiseb River ($26^{\circ} 30' S.$).

North of Rehoboth it occurs sporadically in a belt stretching from the Windhoek district up to Omaruru ($21^{\circ} 25' S.$), with an odd record from Mopane veld near Outjo ($20^{\circ} 07' S.$). It appears to be absent from the Waterberg (not recorded by Sigwart in his careful survey of Outjo and Waterberg in 1914), and from Grootfontein, both of which fall mainly into the Kalahari sand belt. Thus far no tampan has been sent in for the Tick Survey from the Etosha Pan Game Reserve.

Dr. Martin (Geological Survey, South West Africa), who supplied much of the above information, assumes it "to be present throughout the Kaokoveld, as far as there are sandy soils". Thus far we have but one record from the extreme north west corner.

Some tampan has been sent in from Ovamboland (locality not given) with the statement, which I am a bit hesitant to accept, that "it is prevalent throughout".

In Bechuanaland the recorded areas lie west of Longitude 25° and South of Latitude $20^{\circ} S.$, except for an odd record from Kasane on the Chobe-Zambezi River.

RAINFALL AND CLIMATE

Most of the records for the North West Cape and for South West Africa are in areas with an annual rainfall of under 16 in. per annum. For Bechuanaland I have no figures, but as in northern Vryburg and the extreme north-west of Mafeking (according to the maps available) the records fall into areas with a rainfall under 20 in.

The South West Africa records show the sand tampan to be absent from the sub-tropical areas (Gobabis, north of $21^{\circ} S.$, and the Waterberg) and from the tropical areas (Grootfontein and possibly from the greater part of Ovamboland). These climatic conditions presumably are paralleled in the Kalahari sand belt of northern Bechuanaland and of the Caprivi Strip.

In French Equatorial Africa Morel reports it as abundant in the Tchad, with less than 20 in. of rain, throughout the Sahelian Zone; reported mainly from camel routes, 10 to 20 in.

* See Appendix.

VEGETATION

In the North West Cape the records fall mainly into the Kalahari thornveld proper, occurring on deep loose sand over calcareous tufu. This is very open savanna, with the trees *Acacia haematoxylon* and *A. giraffae*, *Boscia albitrunca* and the shrubs *Grewia flavia*, *Lycium hirsutum* and *Rhigozum trichotomum*, with sweet desert grasses, and with a basal coverage of slightly more than six per cent. The tick is absent from the other sub-division of the Kalahari sandveld, i.e. from the Vryburg Shrub Bushveld, which occurs mostly on rocky soils and which varies considerably according to geological formations (e.g. the mixed *Tarconanthus* veld of the Asbestos and Kuruman Hills, and the mixed *Tarconanthus*—Thornveld of the Langeberg and the *Tarconanthus* veld of Vryburg). It is also absent from areas where there is an invasion by the Karroo, as also from the Orange River Brokenveld. In Namaqualand it occurs mainly in the sandy areas of the Karoo-False-Grassveld, or False succulent Karoo. In Bechuanaland and in the Northern South West Africa, it dies out as the Mopane veld and its associated grasses replaces the Kalahari Thornveld.

KALAHARI SAND

The sand in the Kalahari may be 40 to 50 feet in thickness overlying a continuous sheet of calcareous limestones and grits, these rocks becoming richer in lime towards the top and generally exhibiting a hard crust of white limestone. These outcrops are met with in various parts, along the edges of the sand belt, e.g. the Urinani plateau and adjoining regions in the south of South West Africa; the Koranna and Langeberg in Kuruman district, and in the Kaap plateau of Kuruman and southern Vryburg.

"Considering the vastness of the Kalahari region, the uniformity in texture is remarkable, the grain size rarely exceeding 1 mm., and ranging most commonly between 0.15 mm. and 0.4 mm., with the particles not very well rounded" (du Toit, 1939). The sand is alkaline.

For the Kaukaveld, however, it is stated that going northwards there is a change from sandy dunes to rolling plains of sandy loam. As yet I have no information on the sands of Namaqualand and South West Africa. *O. savignyi* is not found in the shadeless clayey soils of the pans.

TEMPERATURE AND HUMIDITY

In *O. savignyi*, according to Lees (1947), the critical temperature for water loss is 75°C (*R. evertsi*, 52°C). The usual wax layer on the skin is "reinforced" with cement deposits, giving a very tough though pliable skin. The cement probably consists of proteins tanned by quinones and intimately associated with lipides of some kind. (Wigglesworth, 1948).

We have no critical aridity/humidity figures, but that temperature and sunlight (apart from starvation) are not the only limiting factors was shown by experimental observations at Onderstepoort. Sandtampans kept at room temperature in shallow sand died very quickly; they survived somewhat longer under 5 in. but could not maintain themselves. If, however, the base of a 12 in. column of sand was kept moist the tampans could maintain themselves easily. They survived for several months in waterlogged soil. Another batch survived in desiccators at 10% to 50% R.H. at room temperature, and fed at the end of two months.

Lees and Beament have shown that unengorged ticks and tampans can take in water even against a moisture gradient, and can withstand being exposed to alternating periods of low humidity with periods of high humidity. The length of this period of adaptation is dependent, not only on the length of the times of exposure, but also on the starvation age of the tick. We have but little information on the starvation-survival-periods for *O. savignyi*, but it can be presumed that, as with most other "desert" Argasids under favourable humidity/tem-

perature conditions, for first stage nymphs it is a matter of six months to a year, or two, and for late stage nymphs and adults, from two years to five—to eight years or more.

In *O. savignyi* in waterlogged soils it would seem that after a while the mechanism regulating water uptake breaks down, because a fair percentage were found to be so bloated as to have (presumably) died from bloat. This did not take place in moist soils, but only in very wet soils. Lees (1944) noticed inactivity of "wireworm" larvae exposed to high moisture in the soil. "The presence of excess moisture, however, also has the effect of inhibiting all muscular activity, this influences the manipulation of the mouthparts and locomotion alike". Possibly there is a similar phenomenon inhibiting the action of the muscles of the spiracle in the Sand Tampan. The temperature figures available to me for the Kalahari are 160° F at the soil surface (180° F for Namib); but at a depth of 2-3 in. the temperature is well below the lethal level for insects; and at a depth of 12 in. or more it remains fairly level not only during the 24 hours but also throughout the year"—(Correspondence).

According to Dr. Martin, "It was observed that Sand Tampans are destroyed if a dense stand of grass under a tree is burned down" and he wonders whether the frequency of veld fires in some areas may not be a limiting factor to the tampan's presence. However, in one experiment, pouring petrol over a kraal with manure, and setting it alight did not eradicate the tampan, which was still present quite near the soil surface after the fire had died down.

"In live dunes of the Namib, especially the large ones, there is a permanently moist bulk covered by a dry layer, which varies in thickness in accordance with the prevailing moisture conditions of the atmosphere; thus in dunes deeper inland this dry layer is thicker than in the Namib dunes in which it is often very thin indeed, the Namib atmosphere has a relatively high moisture content, with sea fogs and heavy dews. In the Kalahari the relative atmospheric moisture is very much lower, dropping to below 5 per cent as against 60-80 per cent in Namaqualand and the Namib at the same time of day"—(Correspondence).

At Mogadiscio (Italian Somaliland) *O. savignyi* is controlled by dampening the court-yards with sea water. It would be of interest to find out whether the deleterious factor is the moistness or the salt.

As yet, I have not plotted the West African, East African or Sudan records. In areas bordering on the Sahara—in the vegetational sudano-sahelian zone—it is possible that the tampan will occur in localities with a higher average annual rainfall. It must, however, be remembered that here the average temperature is possibly higher than in the Kalahari, and also that (in average years) the dry season is drier, due to the hot winds blowing from the Sahara during this time of year (Aubreville, 1960).

PREFERRED HABITAT

O. savignyi avoids exposed sites where the ground temperature may go up to 130° F. It occurs mainly in deep sand in the shade of large-crowned trees, especially the Kameeldoring *Acacia giraffae*. It is also found under the Vaalkameel *Acacia haematoxylon*, under the Witgat *Boscia albitrunca* and the Rosyntjebos *Grewia flava*, if these are large enough to throw good shadows in which animals can shelter.

According to Dr. Martin, "In drier parts of Greater Namaqualand and in the west all along the Namib the Sand Tampan is not confined to the sand-covered areas. It is just as plentiful under trees and bigger bushes in the mountainous tracts, as long as there is a thin veneer of sandy soil, which is practically the case under every bigger bush or tree. The clayey soils support, as a rule, no bigger bushes or trees. The tampan is never found outside the shaded area under a tree, but it is plentiful also in the sandy soil under the shade of rock shelters frequented by game. . . . It does not occur under trees growing in actual beds of dry river courses which are subject to occasional flooding".

It seems agreed that the Sand Tampan avoids sunlight and sand exposed to the direct

rays of the sun, as the sun travels so it follows the tree shade. At Khanzi (Bechuanaland) the farmers consider 25 yd. away from a large tree as a safe distance. Hoogstraal (1956) brings out this avoidance of sunlight very clearly. "At the Khartoum quarantine station one may see a long seething line of thousands of hungry Sand Tampang helplessly confined to the shade of a row of *Acacia* trees. A few yards away, separated only by the hot nine o'clock sun, newly arrived cattle tied to a post fence tempt the Sand Tampang to cross the glaring strip. The next morning in the coolness of seven o'clock those tampang under the trees are all blood-bloated and resting comfortably in the sand, others are dragging back from their hosts across the now non-existent barrier, and the legs of the cattle are beaded with yet other podshaped ticks taking their fill of blood, in a regular line just above the hoof".

In Italian Somaliland and in Berbera the Sand Tampang is said to occur in large numbers in "native huts" and courtyards. In these regions, the living unit is a hut, floor paved or unpaved, having a stone or mudbrick wall surrounding a sandy courtyard, in which the owner plus his fowls and stock all live together. These structures between them apparently offer sufficient shade for the Sand Tampang to maintain itself.

According to Hoogstraal, in the Sudan the tampang at well sides and in native corrals is but superficially burrowed. This would also be the case in the mountainous tracts and rock shelters in South West Africa. What the position is in the deep Kalahari sands of the North Western Cape, Bechuanaland and South West Africa is difficult to say. It has been found at levels down to nine inches. Laboratory observations indicate that it can, and will, go deeper than this.

The evidence in cattle kraals and in stock yards is often conflicting. Apparently it can maintain itself in these localities if the overlying manure is loose and not compacted, although some farmers state that it would seem that they do not like manure; possibly the thickness of the manure layer is a deciding factor. Whether the urine in the manure has any repellent or deleterious effect has not been ascertained.

SURFACE ACTIVITY

It is agreed that the Sand Tampang will feed equally readily at all hours of the day and night, though most farmers state that it is more active during day time. This observation is not above suspicion for (a) but few farmers are out during the night, and (b) cattle do not feel the need to sleep under trees at night time.

The information offered on seasonal activity is conflicting. It is generally agreed that the tick is most active in summer when it is very dry, and that it is not very prevalent immediately after good rains, although more than one farmer states that it appears during wet periods. "Unfortunately I was unable to send you the specimens required earlier because the recent rains, and the heavy dews at night, keep the sand damp, and what happens to the tampang when the sand is wet is a riddle to me" (Correspondence). According to most observers it is more active during the warm summer than it is during the cold winter months. One farmer remarks: "It is very seldom that you see any large ones during winter. Small ones, however, are not wholly inactive. When the cattle are driven into the pens the smaller tampang are there, only not so many as in summer". Others mention that the tampang comes out on warm days in winter.

It frequently happens that cows that have calved under trees have lost the newborn owing to exsanguination overnight. One farmer lost several head overnight after placing his cattle in a kraal that had not been used for several months. In one instance up to three gallons of engorged tampang were collected alongside of three cows killed by exsanguination.

UNDERGROUND ACTIVITY

Under field conditions the tick has been reported from 3 in. downwards. How deep down it can go has not been established, but apparently it goes fairly deep, for often it takes five minutes or longer before any activity is seen on the surface of the soil. The tampan can travel quite quickly through loose dry sandy soil, but it has much more difficulty in moist soil when the sand particles adhere to one another.

Under experimental conditions it has been found embedded motionless in the moist region of a column of sand. However, it was not ascertained how long these ticks would survive these moist conditions—certainly a few months.

HOSTS

In that *O. savignyi* is a quick feeder it is difficult to establish a host list. It attacks large game, camels, dromedaries, cattle, mules, donkeys, sheep, goats and pigs and man quite readily. Lion, rhinoceros, buffalo and giraffe have also been listed.

Whether the movement of smaller animals is a sufficient stimulus to bring the tampan to the surface still is a moot point. Placing fowls under a tree in itself did not bring forth the tampan, but when the owner sat next to them, it came out quickly. This same observation has been made for small dogs.

Besides calves, kids, lambs and pigs may succumb to tampan bites, but it is not known whether these were by themselves, in a troupe or accompanied by a larger animal. We have no information about springbuck, and smaller animals or ground birds.

Although the sand tampan is a quick feeder (first-stage nymphs engorge in 10–74 minutes, later stage nymphs and adults in 15–30 minutes), it would seem that, nevertheless, it is entirely dependent on its host for dispersal. That this is so is shown by its prevalence in North Africa and elsewhere along camel routes where caravans have plied, or, are still plying; and in South Africa in sales stock yards. In southern Africa game may play a rôle: gemsbuck are frequently seen to stand in the shade of trees under which tampan bites are known to occur. However, if the sun is not too hot and if alternate shade is available they will avoid large trees.

STIMULUS

According to field and laboratory observations the tampan responds to soil vibrations very quickly. But often in the laboratory it has been observed to appear on the surface independently of any vibrations, and, since the jars of soil were under constant laboratory conditions, these appearances were independent of any increase in soil surface temperature, nor did these appearances show any constancy nor rhythmic hunger urges.

ENEMIES

Predators in nature do not appear to have been reported. Under laboratory conditions rats have been known to feed on nymphs and on adults. Mice commonly assault nymphs, but only particularly bold individuals attack adults. These rodents, in turn, easily escape blood-thirsty but lumbering adults, although small active nymphs more easily attach to them. One farmer states that since he has introduced guinea fowls onto his farm he has not been troubled by Sand Tampan. The question may be put whether in the more heavily populated areas, it is not only the increase in the food potential, but also, or rather, the decrease of the game birds, quail, guinea fowl, partridge, sandgrouse and francolins, which has led to the build-up of the Sand Tampan infestation. Domestic fowls have been seen feeding on the Sand Tampan.

DISCUSSION

Control

Any control method to be useful must meet the four requirements: (1) it must kill the tampan; (2) it must have a long residual effect; (3) it must not kill shade giving trees; (4) it must be economical and easily applied.

As yet we do not know the temperature and/or humidity preferences of the tick, but assuming that it likes a constant temperature and a fairly high humidity it would appear that it would be "at home" in the sand at a depth between 12-24 in. (30-60 cms.). At Mata Mata in the Gemsbok National Park air humidity at 5 p.m. falls to 9 per cent rising to 42 per cent overnight. In the Namib comparable figures are 35 per cent and 95 per cent, so that in the Kalahari the tick would normally burrow deeper down than it does in the Namib.

In so far as water is never abundant, insecticides in powder form, or as granules, would have preference over emulsions or wettable powders, as also over soil fumigants, which need a sealing layer of water.

If insecticides are to be used, to be economical, the less sand they are mixed with the better. Thus some method must be devised, not only to bring the tick to the surface but to keep it in the top few inches. This could be done by keeping the surface soil moist and "mild", possibly by the application of a thick layer of sawdust or of humus (scarce in the tampan veld), or possibly by spreading sheets of plastic in the shade of the trees, or possibly by the application of some water-holding clayey or colloidal substance (uneconomical and possibly harmful to the trees).

It would appear that fencing off the shade of trees and enclosing fowls that scratch, offers some hope of success. Starving out any tampan is almost an impossibility in that the starvation-survival periods are long. If *O. savignyi*, for which we have but scant information, runs true to tampan form it can stay without food for quite a few years.

Changing grazing and animal husbandry practices, it appears to me, should help considerably. On many farms the cattle range during the night and are coralled by day. In the course of time, hence, the kraals, positioned at the waterpoints, become heavily infested, the cattle providing the shade necessary for the tampan during the day. In some instances the cattle range by day and are coralled at night. During the heat of the day the cattle seek available shade and are attacked. Either way, they meet up with the tampan. Carting water over the sandy stretches would be uneconomical. It would seem that the most feasible solution would be, in these days of plastic piping, that the day kraals and their water troughs should be moved from time to time and the manure in the old kraals removed leaving the kraal soil surface exposed to the sun. This would entail less work and wire than would fencing off all the shade trees on the farm/ranch.

Herding of cows-in-calf is indicated, with the provision of moveable shelters in a specially prepared camp, so that cows do not have to look for the shade of trees.

To await the advent of a guaranteed foolproof insecticide is courting trouble, whereas changing of grazing habits and introducing sound animal husbandry practices offers some measure of relief and of control.

ADDENDUM

A fleeting visit of one day (14.7.61) to Allemanskraal, Steytlerville district, since writing this article, has shown that the ecological background and the behavioural pattern of the tick in this area differs slightly from that in the North West Cape.

Allemanskraal, 33° 14' S., 24° 15' E., 1,400 ft. above sea level, in the Grootrivier Range, has an annual rainfall of 7-97 in. with a slight fall every month, the winter being drier than the summer. The average yearly temperature is about 66°F, rising into the hundreds during the seven

summer months, averaging a yearly minimum of 56°F with an absolute minimum of 30°F. Heavy frost is seldom experienced.

The vegetation is typical Noorsveld; "a uniform 4-6 ft. high scrub of clusters of grey, shrubby, succulent, spiny *Euphorbia caerulea* (Noors), dotted with small trees; the largest of these small trees are mostly the dark small-leaved *Pappea capensis* (the Pruim or Berg Pruim). Interspersed amongst the dominant Noors are various species of inconspicuous shrubs. In the shelter of these shrubs one can still find some Karroo herbs and grasses. Owing to the ability of goats to eat chopped *Euphorbia caerulea*, as a last resort during drought, this veld type has suffered particularly badly from overgrazing, and in its present condition is often seen dimly through a dust storm" (Acoccks 1953). The soil at Allemanskraal is mainly clayey and is mostly beaten, or tramped, hard between the Noors clusters.

The Sand Tampan, according to Mr. Hayward's experience, borne out by our one day visit, is found under the larger *Pappea capensis* where there is a loose layer of soil. This layer in many instances is less than $\frac{1}{2}$ in. deep, in others it may be up to 3 in. Under no tree did we find any greater depth of loose soil.

Tick activity under the trees was variable; under some there was no response or but little response to our presence (*i.e.* trees known to harbour the Sand Tampan). Under one the response was so overwhelming that eventually we had to beat a retreat on to safe ground.

Invariably the first ticks to come above ground were the younger-stage nymphs; the larger nymphs and adults appeared much later. Some adults apparently travelled under ground, for they were only found at soil surface underneath where we had been sitting. Obviously freshly engorged Sand Tampans were found hidden very superficially either under a very thin layer of dust or under a few small dry leaves. As often as not the tampans were well beyond the shade of the trees. The air temperature was 71°F. The soil, however, was not hot to the touch.

In his experience, Mr. Hayward has not found the tick on either his cattle, goats or sheep, but he has found them on kudu, which frequently rest under the Pruim trees.

It is to be anticipated that the tick is to be found throughout the Noorsveld. That it has only recently been recorded from the area may possibly be explained by the herding practices (or the lack of herding practices) which obtain. Its abundance at Allemanskraal points to a long established presence.

The Steytlerville Noorsveld tampan is thus seen to show slight differences from the Kalahariveld tampan, in that it exists in shallow layers of sand, under smaller trees (just about big enough to offer shade to one resting Kudu) has no objection to a (temporary) appearance in the sun, and is active all the year round. The observation that it is the young stages that appear first, confirms the finding in other regions that it is the young that are most active.

Dr. W. G. Walton, writes to say that the Noorsveld tick shows a few slight taxonomic differences from the Egyptian tick.

ACKNOWLEDGEMENTS*

This article is based on the Sand Tampan Survey: material and information sent in in reply to circulars to State Veterinarians in October 1956 and in August 1960. I thank these officers and their Stock Inspectors: as also members of the Division of Botany, of the Transvaal Museum, and of the Geological Survey, especially Dr. H. Martin stationed at Windhoek, for their co-operation. Also, I thank Dr. K. Unsworth, Director of Veterinary Services, Bechuanaland for his assistance in obtaining information from his territory.

*I thank W. J. Hayward for the information supplied and for his hospitality during our short stay at Allemanskraal.

SUMMARY

The geographical distribution is given. Its distribution in southern Africa is analysed: here it is shown to be present mainly in deep sand, but may occur in shallow sand in rock shelters. In the North Western Cape it is mainly associated with the shade of *Acacia giraffae* and *A. haematoxylon* of the Kalahari thornveld; and in Little Namaqualand it is associated with the shade of the larger trees of the Karoo-false-grassveld. It occurs in regions having less than 20 in. rain per annum; it avoids direct sunlight, cannot exist in dry sand; it is not known to what depth it penetrates into the sand nor what its preferred pH is. Small animals play no rôle, or but a minor rôle as hosts: their weight and movements being inadequate to cause vibrations of the earth which appear to be the main stimulus to bring the tampan above ground.

Control measures. In view of the scattered distribution over a very large area, the depth of the sand and of the lack of water in these areas, measures necessitating the use of water are impracticable and uneconomical, thus ways and means will have to be found either (1) of changing the nature of sand, or (2) of bringing the tampions to, and keeping them at, the soil surface, where specific insecticides having long residual values could be applied and or (3) of changing grazing habits and of introducing sound animal husbandry.

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DISCUSSION

Mr. Bateman: With regard to the effects of vibration, similar responses may be observed in other animals having an underground habitat. I have some evidence that golden moles may come to the surface when stimulated by small vibrations such as might be produced by earthworms. However, once on the surface, they seem to have no direction-finding apparatus but to search for their food at random.

Dr. Winterbottom: Have you direct evidence that Guineafowl eat tampions?

Dr. Theiler: Some, yes.

Dr. Bigalke: In the Kalahari there is a big gap in the distribution of Guineafowl.

Mr. Attwell: Are there no other birds, such as the dry-country francolins, which might take over in the absence of Guineafowl?

Dr. Theiler: It is only a theory of mine that the increase in the tick may have accompanied the killing off of game birds.

Dr. McLachlan: Would it not be possible to control these ticks by bringing them to the surface by means of a simple vibrating device and then spraying.

Dr. Theiler: Very possibly, but there has been no work on such control methods in the field as yet.